Submitted to

Los Angeles County

City of Norwalk ATMS
System Architecture Diagram – Final
(Deliverable 2.1.5.4)

Gateway Cities Traffic Signal Synchronization and Bus Speed Improvement Project - I-105 Corridor (Phase II)

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NATIONAL ENGINEERING
TECHNOLOGY CORPORATION

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1. INTRODUCTION

The purpose of this document is to develop a detailed design for the Advanced Traffic Management System (ATMS) for the City of Norwalk as part of the I-105 corridor project. This document is based on the recommendations included in the *I-105 Corridor - Draft Conceptual Design Report*. The City of Norwalk is one of the cities within the I-105 corridor area that is planned to be a contributor of traffic data to the Information Exchange Network (IEN). The system architecture for the I-105 corridor is shown in **Error! Reference source not found.**. Norwalk is highlighted to indicate where this agency fits into the overall system. This system architecture is decomposed for the City of Norwalk into each system component that comprises the Norwalk ATMS. Subsequently each component is further decomposed to develop a detailed design that will result in a list of required equipment and the allocation of system components to the various procurement vehicles for implementation in the City of Norwalk.

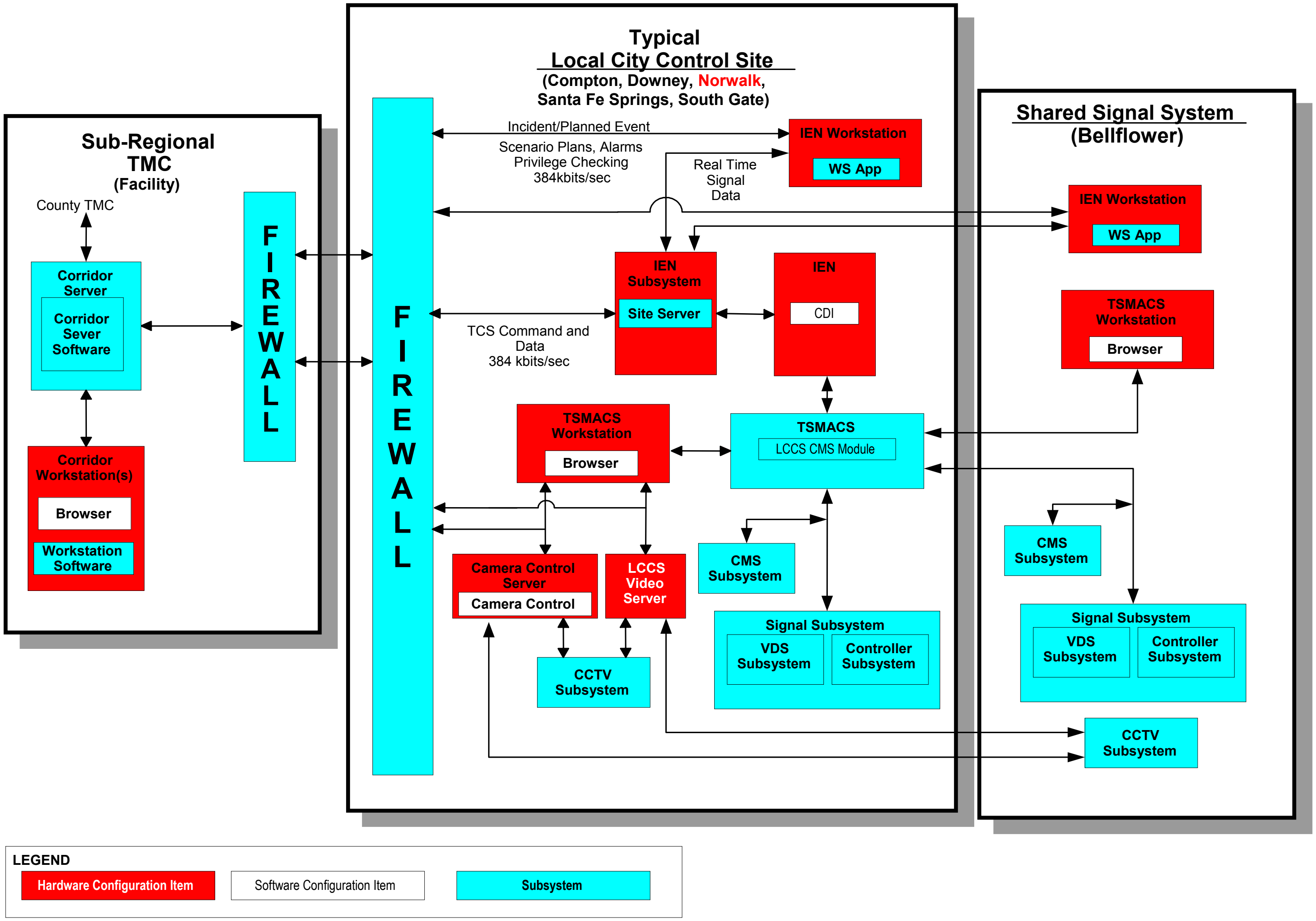

Figure 1-1: I-105 Corridor System Architecture

2. CITY OF NORWALK ADVANCED TRAFFIC MANAGEMENT SYSTEM (ATMS)

The Advanced Traffic Management System (ATMS) for the City of Norwalk consists of three subsystems: traffic signal subsystem and the video subsystem, and the communications subsystem that supports both of them. The configuration items in Figure 1-1 that are addressed in this document can be assigned the ATMS subsystems for the City of Norwalk as follows:

Traffic Signal Subsystem:

- Traffic Signal Monitoring and Control Subsystem (TSMACS)
- Controller Subsystem
- Vehicle Detection Station (VDS) Subsystem

Video Subsystem:

- Camera Control Server
- Video Server
- CCTV Subsystem

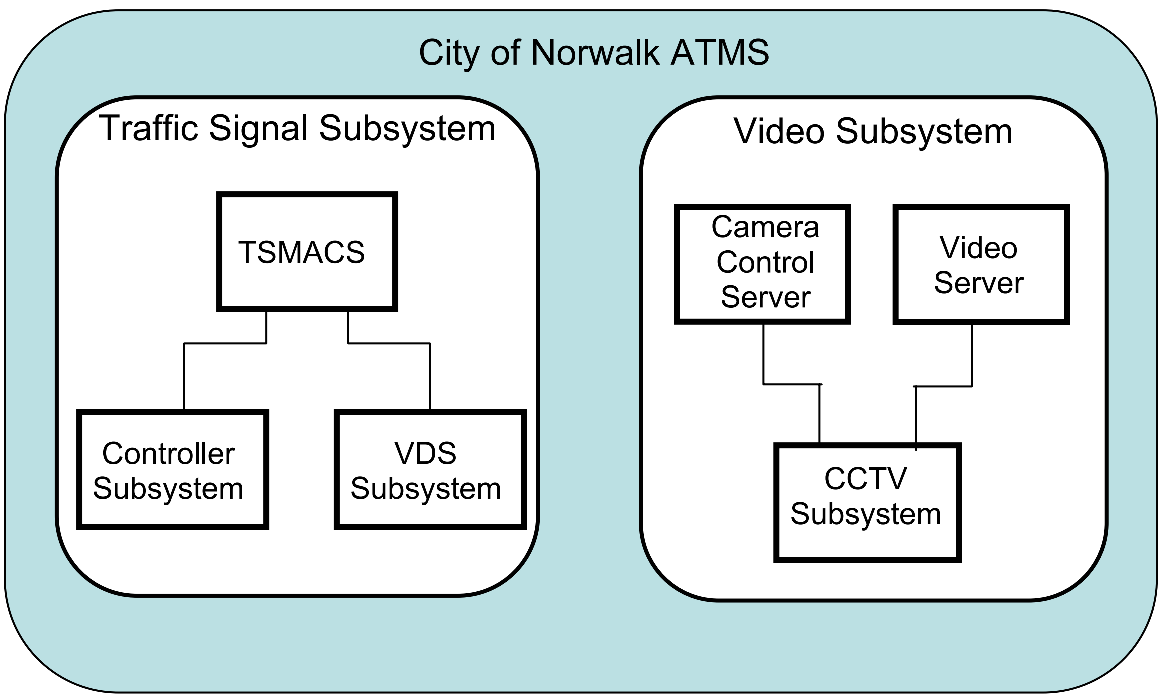

Figure 2-1: Norwalk ATMS System Architecture

The field components include CCTV cameras at signalized intersections and traffic signal controllers that are to be connected to the TSMACS.

Fiber optic communications cable is proposed to be installed in the City of Norwalk, shown in Figure 2-2, as follows:

- Along Firestone Blvd. between Stewart & Grey Rd and Imperial Hwy.
- Along Imperial Hwy between Firestone Blvd. and Bloomfield Ave.

The new fiber proposed along Imperial Hwy between Transportation Center Driveway (West) and Carmenita Rd. is in the City of Santa Fe Springs. The field equipment (traffic signal controllers and CCTV cameras) will be connected to the Santa Fe Springs LCC using this fiber optic cable. The CCTV camera located at Imperial Hwy/Carmenita Rd. will be connected to the County TMC via fiber optic cable to the nearest telephone access point where the fiber will be converted to leased-lines.

Figure 2-2: Proposed Fiber Optic Cable Routing and CCTV Locations in Norwalk

2.1 Traffic Signal Subsystem

The traffic signal subsystem consists of three components: the Traffic Signal Management and Control System (TSMACS), traffic signal controllers, and vehicle detection stations (VDS). In the following subsections, a functional description and the proposed design approach is provided for each component of this subsystem. Figure 2-3 depicts the equipment interconnection for the traffic signal subsystem. The traffic signal controllers collect traffic flow data from the advance detectors.

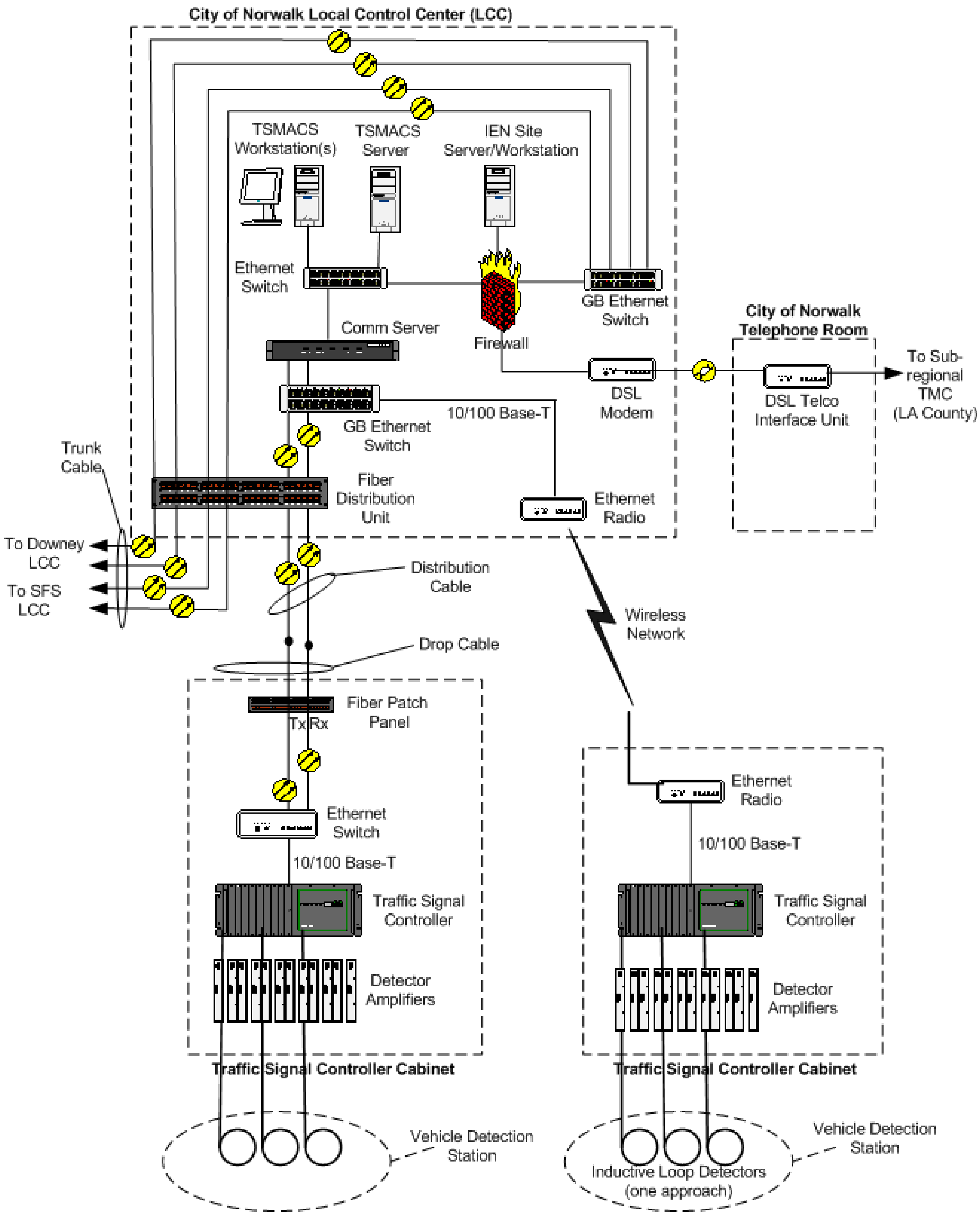

Figure 2-3: Traffic Signal Subsystem Physical Architecture Diagram

2.1.1 Traffic Signal Management and Control System (TSMACS)

The TSMACS provides the monitoring and control of traffic signals and interfaces with the traffic signal controllers. Functional requirements were developed during the high-level design phase for I-105 Corridor project. These requirements can be grouped into the following areas:

- Traffic Signal (TS)
- Information Exchange Network (IEN)
- User Interface (UI)

Traffic Signal (TS):

TS functional area consists of the functionality related to traffic signal monitoring and control, as well as traffic data archiving and reporting.

Information Exchange Network (IEN):

The IEN area consists of requirements related to providing a data interface between the TSMACS and an external system. This allows the IEN to retrieve traffic data from each TSMACS for overall corridor coordination.

User Interface (UI):

The UI area consists of functionality related to the graphical user interface, such as dialogs and map displays for the TSMACS to control and monitor field equipment.

The selected TSMACS may not meet all functional requirements using an off-the-shelf software package. The I-105 Corridor Conceptual Design Report specified three vendor offerings that could provide the City of Norwalk with their TSMACS. These are as follows:

- Econolite *icons*
- Siemens i2TMS
- Transcore Series 2000 (or Transuite)

Technical specifications for the selected TSMACS will be provided in *Deliverable 2.1.5.1 - Norwalk Draft ATMS Specification and Scope of Work.*

2.1.2 Traffic Signal Controllers (TSC)

2.1.2.1 Functional Description

The traffic signal controllers are various models from Econolite. There are 31 traffic signal controllers to be connected to the TSMACS, these controller locations are listed in Table 2-1 along with the proposed upgrade and the type of communications to be used.

Table 2-1: Controllers Proposed to be connected to TSMACS

No.	Primary Street	Cross Street	Controller Type	Communication
1	Firestone Blvd	Target Dwy	ASC/2-2100	Fiber
2	Firestone Blvd	Studebaker Rd	ASC/2-2100	Fiber
3	Firestone Blvd	Albertsons Dwy	ASC/2S-2100	Fiber
4	Firestone Blvd	Imperial Hwy	ASC/2S-2100	Fiber
5	Imperial Hwy	Jersey Ave	ASC/2S-2100	Fiber
6	Imperial Hwy	Pioneer Blvd	ASC/2S-2100	Fiber
7	Imperial Hwy	Kalnor Ave	ASC/2S-2100	Fiber
8	Imperial Hwy	Norwalk Blvd	ASC-8000	Fiber
9	Imperial Hwy	AVD Manuel	ASC/2S-2100	Fiber
10	Imperial Hwy	Volunteer Ave	ASC-8000	Fiber
11	Imperial Hwy	Ralphs Dwy	ASC-8000	Fiber
12	Imperial Hwy	Bloomfield	ASC/2S-2100	Fiber
13	Firestone Blvd	Woods Ave	ASC/2S-2100	Wireless
14	Firestone Blvd	Pioneer Blvd	ASC/2S-2100	Wireless
15	Firestone Blvd	San Antonio Dr	ASC-8000	Wireless
16	Imperial Hwy	Curtis & King Rd	ASC/2S-2100	Wireless
17	Imperial Hwy	Food for Less Dwy	ASC-8000	Wireless
18	Imperial Hwy	Studebaker Rd	ASC/2S-2100	Wireless
19	Rosecrans Ave	Studebaker Rd	ASC/2-2100	Wireless
20	Rosecrans Ave	Harvest Ave	ASC/2-2100	Wireless
21	Rosecrans Ave	Flallon Ave	ASC/2-2100	Wireless
22	Rosecrans Ave	Pioneer Blvd	ASC/2-2100	Wireless
23	Rosecrans Ave	Clarkdale Ave	ASC/2-2100	Wireless
24	Rosecrans Ave	Funston Ave	ASC/2-2100	Wireless
25	Rosecrans Ave	Norwalk Blvd	ASC/2S-2100	Wireless
26	Rosecrans Ave	Shoemaker Ave	ASC/2S-2100	Wireless
27	Rosecrans Ave	Carmenita Rd	ASC-8000	Wireless
28	Studebaker Rd	Lyndora St.	ASC/2-2100	Wireless
29	Studebaker Rd	Littchen St.	ASC/2-2100	Wireless
30	Studebaker Rd	Foster Rd.	ASC/2S-2100	Wireless
31	Studebaker Rd	Leffingwell Rd.	ASC-8000	Wireless

2.1.2.2 Design Approach

Traffic signal controllers that are to be connected to the TSMACS are proposed to use fiber optic or Ethernet radio communications technology. The communications interfaces that link the controllers to the Norwalk LCC are described in Section 2.3.

2.1.3 Vehicle Detection Stations (VDS)

2.1.3.1 Functional Description

Vehicle detection station is a term that is used to describe a set of advance vehicle detectors on a single intersection approach. These detectors are typically about 300' to 400' from the intersection (depending on approach speeds) and are located in each adjacent lane. These vehicle detectors measure volume, occupancy, and speed or VOS (speed may be derived by the system) to allow the TSMACS to adjust timing when operating in a traffic-responsive mode. These vehicle detectors are also used for extending the green interval on a given phase when the controller is operating in free operation mode. The VOS data is typically retrieved by the TSMACS at end of a cycle or fixed frequency and used for traffic flow analysis or timing adjustments. The VOS data is also retrieved by the external systems such as the Information Exchange Network (IEN) to allow other agencies in the corridor to monitor traffic flow conditions on arterials that cross jurisdictional boundaries. In some cases, detectors in separate lanes share a single Detector Lead-in Cable (DLC). A VDS with this configuration produces VOS data that is not as accurate as VDS locations, which have a separate DLC for each lane. Several signalized intersection approaches are proposed to have additional DLC added to allow the VDS to measure VOS data from individual lanes. These intersections will be specified in the Plans, Specifications, and Estimate package.

2.1.3.2 Design Approach

Typically, when adding DLCs to an existing conduit run, the existing DLC must be removed and re-installed with the new cables. An additional detector amplifier is also required for each additional DLC to provide a separate input channel to the traffic signal controller.

2.2 Video Subsystem

The video system consists of the following components:

- CCTV Controller
- Video Server
- CCTV Subsystem

Figure 2-4 depicts the physical architecture for the video subsystem. The CCTV cameras utilize two types of communications for the link to the LCC; fiber optic cable and leased-line.

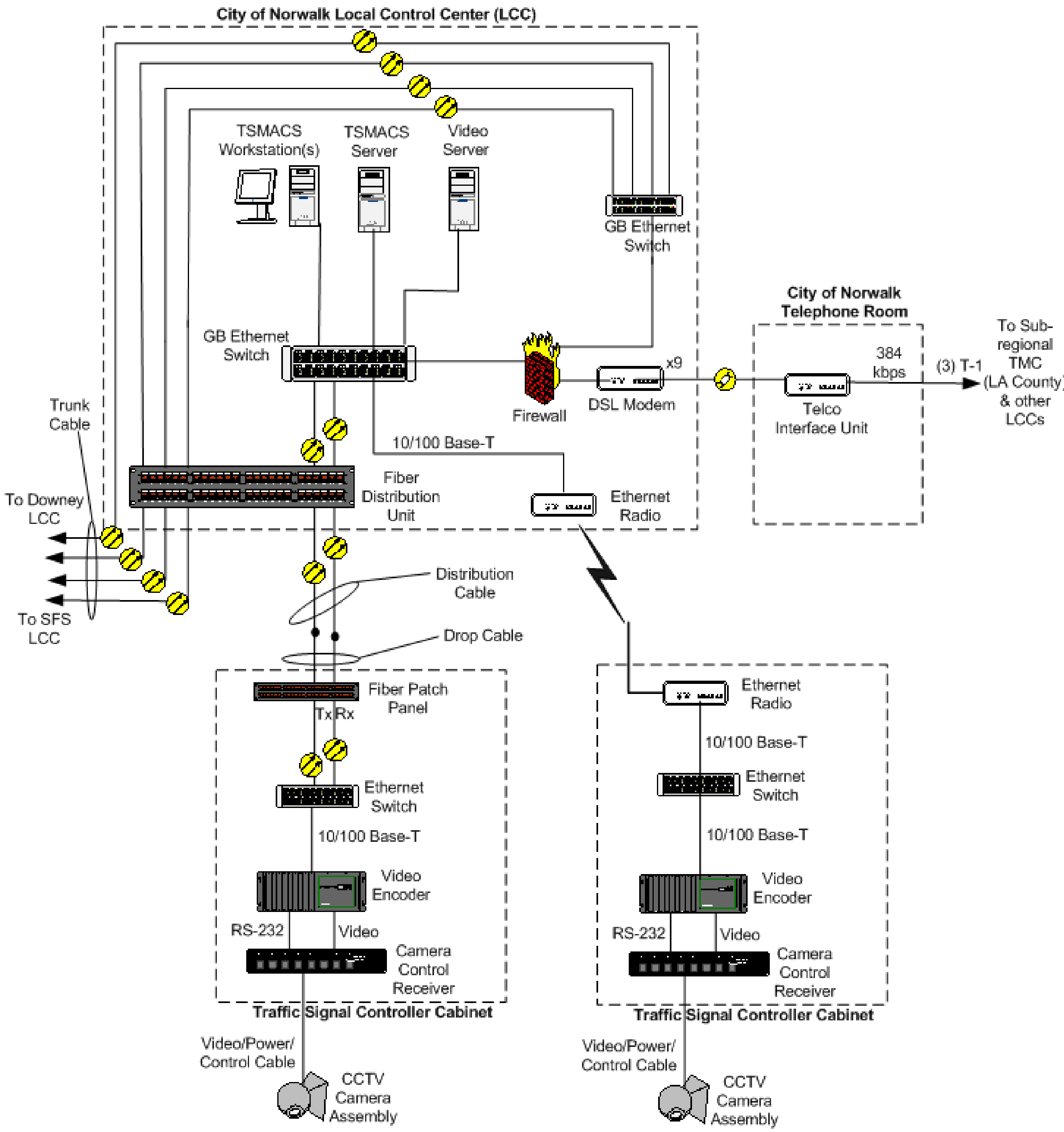

Figure 2-4: Video Subsystem Physical Architecture Diagram

2.2.1 Video Server

2.2.1.1 Functional Description

The Video Server consists of two basic components: video distribution and CCTV camera control. The Video Server is included as part of the TSMACS package. The video distribution component provides the Norwalk ATMS with the ability to collect the video images from the cameras in the field and distribute the images to display devices within the LCC and to other agencies in the I-105 corridor. The CCTV control component provides the ATMS with the ability to remotely control CCTV cameras from the Local Control Center (LCC). Control functions generally consist of panning, tilting, zooming, focus, iris, pre-set positioning, color balancing, and other features.

2.2.1.2 Design Approach

This Video Server is currently under design as part of Task 7, therefore this document addresses this component at a high-level. The City of Downey currently employs Video over IP technology for collection of video surveillance images from CCTV cameras in the field. Each video channel is digitized and transferred to the LCC over an IP-based fiber optic backbone network. It is proposed that the City of Norwalk be consistent with this approach for two reasons: 1) to facilitate the exchange of video images with Downey and other agencies in the I-105 corridor, 2) to have a consistent design within the PS&E package that is installing this system (which traverses three cities with fiber optic cabling and CCTV cameras). The IP-based network acts as a video switching network by allowing users to select cameras and route the images to the desired display device. Each camera and display device has an associated IP address. Camera selection commands by the end-user are actually seen as origin and destination IP addresses by the IP-based network. A video server may provide this translation and to distribute the images from Norwalk to other agencies in the corridor. Due to the fact that these images may be transferred over both fiber optic networks and low-bandwidth networks, MPEG-4 or MJPEG encoding may be best suited for application in the City of Norwalk.

The CCTV camera control function consists of a user interface (either joystick or computer graphical user interface) communicating with a CCTV controller unit or server to send commands to the camera control receiver in the field. The communications link that supports the transfer of camera control commands between the LCC and the CCTV camera is combined with the video on the same Ethernet link. CCTV camera in the field is typically a serial interface. However this serial communications can be accommodated by a terminal server to allow data transfer over an IP-based backbone network between the LCC and the field equipment.

2.2.2 CCTV Subsystem

The CCTV subsystem consists of the CCTV camera field equipment located at selected signalized intersections.

2.2.2.1 Functional Description

The CCTV subsystem consists of the CCTV camera field equipment located at selected signalized intersections. The intersections listed in Table 2-2 are proposed to have CCTV camera locations.

Table 2-2: Proposed CCTV Camera Locations for Norwalk

No.	Cross Street	Communications
	Firestone Blvd.	
1	Imperial Hwy	Fiber
2	Studebaker Rd.	Fiber
3	Pioneer Blvd.	Ethernet Radio
	Imperial Hwy	
4	Bloomfield Ave.	Fiber
	Rosecrans Ave.	
5	Studebaker Rd	Ethernet Radio
6	Pioneer Blvd.	Ethernet Radio
7	Carmenita Rd.	Ethernet Radio

The CCTV subsystem allows operators at the Norwalk LCC to view video surveillance images at signalized intersections and control the position of these cameras for an optimum field of view for all approaches.

2.2.2.2 Design Approach

The CCTV camera location consists of the following equipment:

- CCTV camera assembly (camera, lens, pan-tilt unit) inside an environmental enclosure.
- Camera Control Receiver Unit
- Video Encoder
- Ethernet Switch
- Fiber Patch Panel
- Ethernet Radio (for wireless locations)

CCTV Camera Assembly

The design approach for CCTV camera locations is to mount a dome enclosure to an existing traffic signal pole just below the mast arm, as shown in Figure 2-5. The enclosure houses the camera, lens, and pan-tilt unit. A single cable egress is to be installed to allow a hybrid cable to be installed between the camera control receiver unit in the existing traffic signal cabinet and the CCTV dome enclosure. The hybrid cable consists of multi-conductors for camera control and power, as well as a coax cable for video transmission all contained within an outer jacket.

CCTV Interface Equipment

The CCTV interface equipment is to be located in the existing traffic signal controller cabinet where space allows. Otherwise a new cabinet will be required at the intersection to house the new equipment. This equipment consists of a camera control receiver unit which converts camera control commands to motor voltage levels for the lens and pan-tilt unit. This unit also provides a video output port and camera control panel to reduce the need for a bucket truck during maintenance activities. A video encoder is used to convert the analog video signal sent from the camera into digital video for transmission on an IP-based network to the LCC. The encoder also functions as a terminal server to provide a serial interface for camera control commands. An Ethernet switch is used to provide network access for devices in the equipment cabinet. The video encoder feeds the digital video into this switch. A fiber distribution unit is also installed in the cabinet to terminate the 6-strand fiber optic drop cable in the equipment cabinet. A duplex fiber optic path cord is used to connect to the Ethernet switch.

For CCTV camera locations that are utilizing wireless communications to transmit the video images back to the Norwalk LCC, an Ethernet Radio is required in the equipment cabinet.

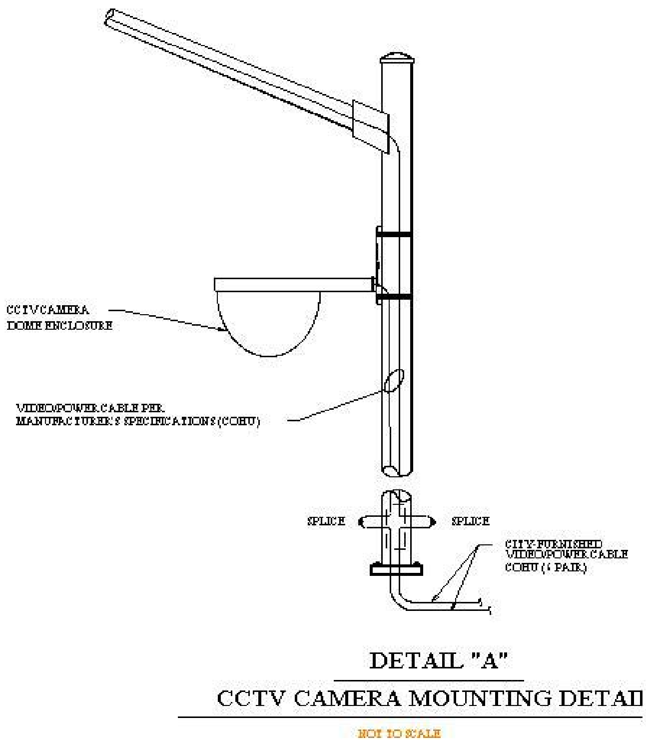

Figure 2-5: CCTV Dome Enclosure

2.3 Communication Subsystem

The communications subsystem supports the Traffic Signal and Video subsystem. There are two categories used to describe the communication subsystem for the City of Norwalk: 1) center-to-field and 2) center-to-center. Center-to-field is the part of the communication system that links the field equipment to the LCC for the transfer of data and video images. Center-to-center is the part of the communication system that links the Norwalk LCC with other agencies' LCC in the I-105 Corridor.

2.3.1 Center-to-Field

There are two types of technologies proposed for the Norwalk ATMS communications infrastructure: fiber optics and spread wireless Ethernet radio.

2.3.1.1 Fiber Optics

Two fiber optic cables run along Firestone Blvd. in the City of Downey. This configuration is continued within the City of Norwalk. A fiber optic cable, referred to as the backbone, consisting of 24 fibers, is used to interconnect the communications hub to the Norwalk LCC and to interconnect the Norwalk LCC with the Downey LCC and the Santa Fe Springs LCC. There is also a distribution cable containing 48 fibers that serves to interconnect controllers and CCTV cameras to the communications hub or Norwalk LCC.

Fiber optic cable will interconnect CCTV cameras and traffic signal controllers along Firestone Blvd. and along Imperial Hwy. Each CCTV camera has a camera control receiver, a video encoder, and an Ethernet switch that allows camera control data and digital video to be transported over IP-based network via a communications hub, which serves a concentrator node for video sent to the Norwalk LCC (see Figure 2-6). The CCTV cameras linked to the Santa Fe Springs LCC are shown for reference.

2.3.1.2 Wireless

In order to link signalized intersections and CCTV cameras that are not located along the proposed fiber optic cable route, a wireless Ethernet radio communication system is proposed. This allows a high-bandwidth throughput for digital video transmission and "second-by-second" data transfer for traffic signal status. A wireless Ethernet radio is to be installed in the cabinet with a small antenna and a 10/100 Base-T connection is made to the traffic signal controller to an Ethernet Switch. The traffic signal controller will be upgraded with an Ethernet interface, so no conversion is needed from RS-232 interface.

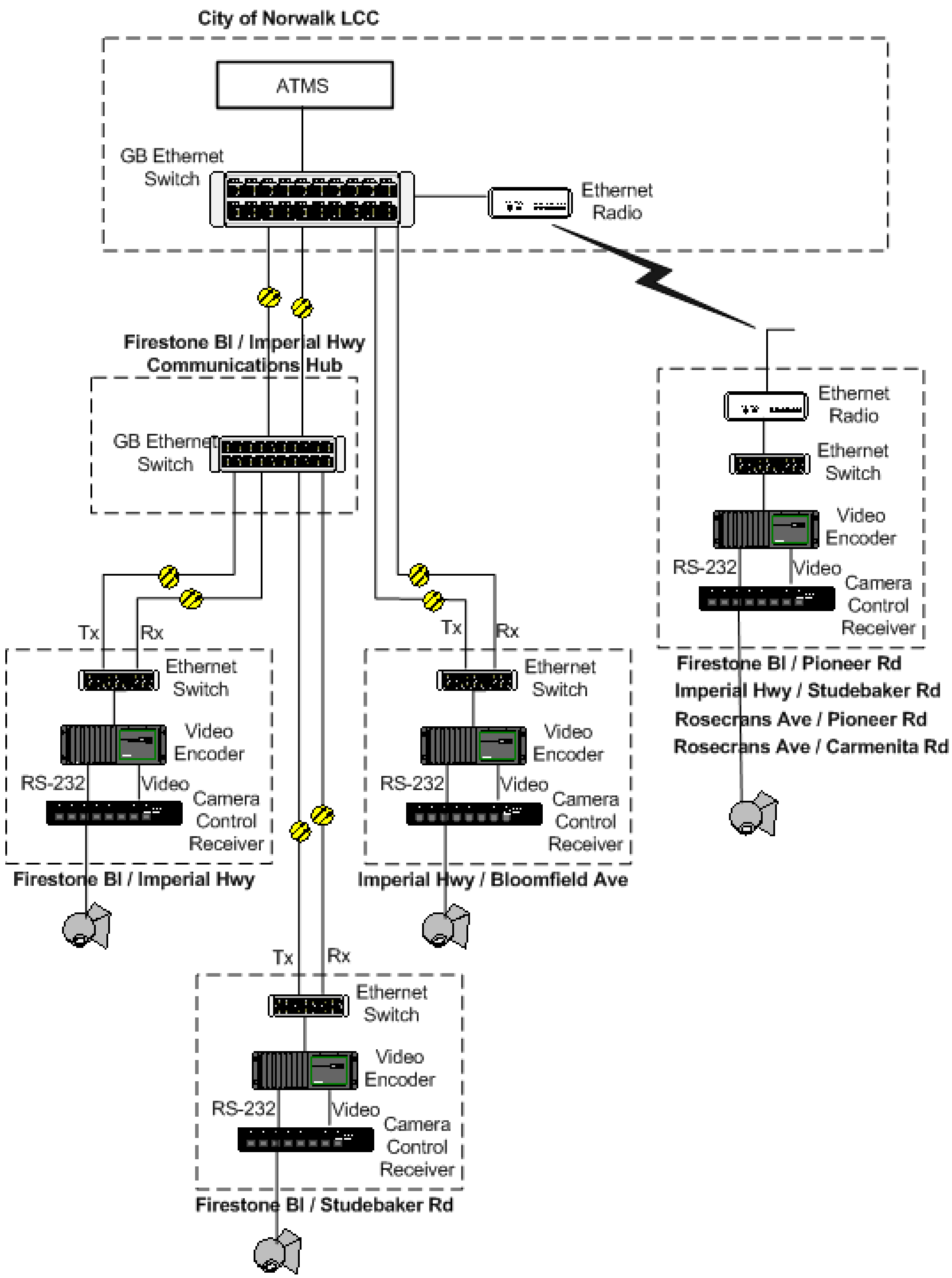

Figure 2-6: Communications Architecture (Center-to-Field) for Video Subsystem

Ethernet switches in each cabinet are used to connect the traffic signal controllers to the ATMS at the Norwalk LCC, as shown in Figure 2-7. Each Ethernet switch connects to the Ethernet port on the controller and two fibers (transmit and receive) are utilized along the distribution cable. The Ethernet switches are interconnected to create a star topology to minimize the impact of a device failure to the other controllers along the cable route. The traffic signal controllers not connected to fiber are to be linked to the LCC using Ethernet radio communications.

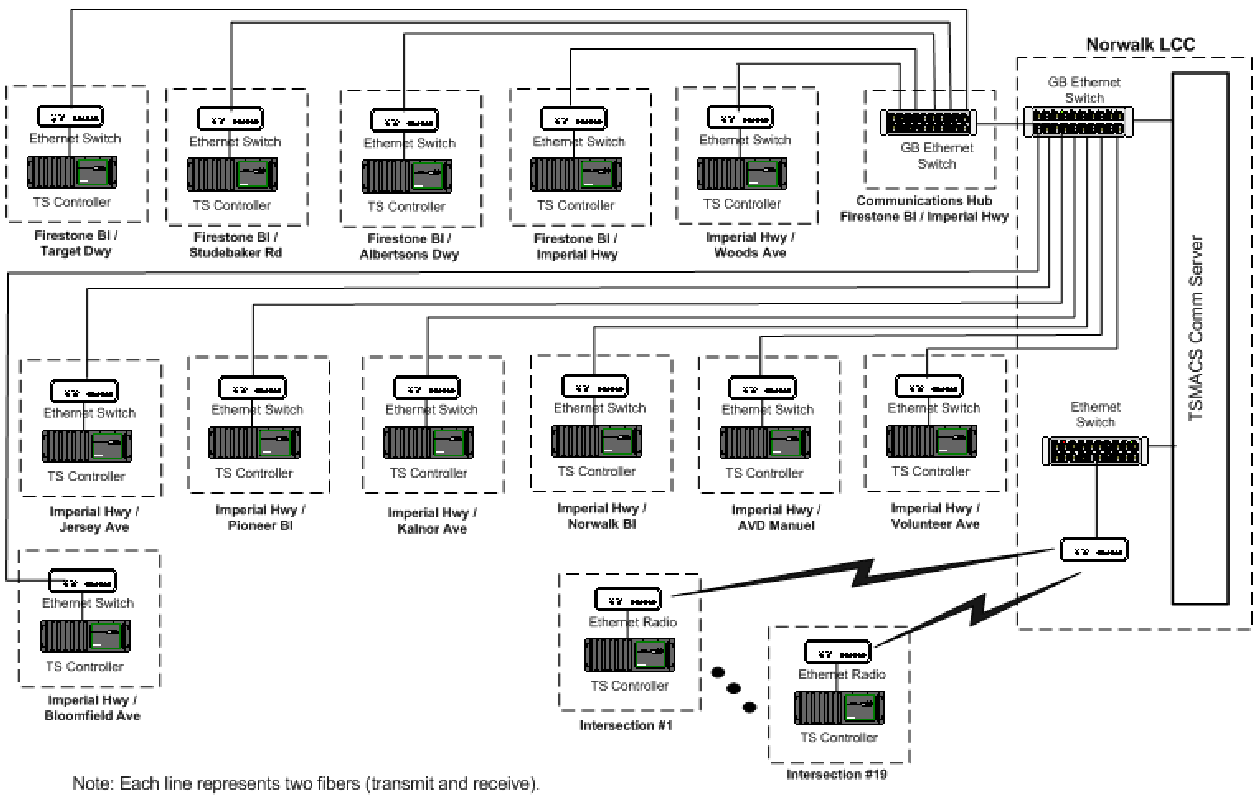

Figure 2-7: Communications Architecture (Center-to-Field) for Traffic Signal Subsystem

2.3.2 Center-to-Center

There are two types of communications proposed to support the exchange of data and video between the Norwalk LCC and other agencies' LCC. Fiber optic is used to interconnect the cities of Norwalk, Downey, and Santa Fe Springs. DSL lines are proposed to link the Norwalk LCC to the remaining cities in the I-105 Corridor.

2.3.2.1 Fiber Optics

A fiber optic backbone ring configuration between Norwalk, Downey, and Santa Fe Springs is formed by connecting gigabit Ethernet switches located at each of these nodes and may employ spanning-tree protocol for redundancy.

2.3.2.2 Leased-lines

DSL lines are used to link the Norwalk LCC to the LCCs of Paramount, Lynwood, Compton, Southgate, Bellflower, and the sub-regional TMC at LA County. A single, 384 kbps line is dedicated for data exchange between these facilities. A 384 kbps DSL line is also allocated between Norwalk and each of these agencies to allow a single video channel to be set up between each agency.

3. LIST OF EQUIPMENT FOR NORWALK LOCAL CONTROL CENTER (LCC)

Table 3-1 lists the equipment to be installed in the Norwalk LCC. Rack elevations and console layout are provided in *Deliverable 2.2.0 – Specifications for Console and Racks*. The floor plan layout for the Norwalk LCC is provided in *Deliverable 2.2.9 Norwalk Draft Site Report & LCC Layout*

Table 3-1: List of Equipment located in Norwalk Local Control Center

No.	Item Description	Qty	Mounting	Supplied by
1	TSMACS Application Server	1	Rack	TSMACS Vendor or City
	TSMACS Video Server	1	Rack	TSMACS Vendor or City
2	TSMACS Workstation	2	Desktop/Tower	TSMACS Vendor or City
3	TSMACS Comm Server	1	Rack	TSMACS Vendor or City
4	IEN Site Server	1	Rack	IEN Project
5	IEN Workstation	1	Desktop/Tower	IEN Project
6	GB Ethernet Switch (Norwalk)	1	Rack	TSMACS Vendor or City
7	GB Ethernet Switch (Inter-Agency)	1	Rack	FO Construction Project
8	Ethernet Switch (LAN)	1	Rack	TSMACS Vendor or City
9	DSL Modems	9	Rack	IEN Project
11	Video Display	1	Desktop/Wall	City
12	Fiber Distribution Unit	1	Rack	FO Construction Project
13	Video Decoder	1	Rack	FO Construction Project
14	Firewall	1	Rack	IEN Project